the echelon, the Fabry and Perot interferometer, &c. Those workers wishing to learn more of the latest forms of these special apparatuses should get section B of the catalogue, issued separately, in which, in addition to the descriptions, figures, and prices, complete bibliographies concerning them are given.

WE have received the new edition of the "Descriptive List of Photographic Dry Plates, Filters, and Safelight Screens" manufactured by Messrs. Wratten and Wainwright, Ltd. (Croydon). The firm have recently installed apparatus for the critical examination of the effect of colour screens upon definition, a matter too often left to chance. With regard to the plates, &c., prepared specially for all kinds of scientific work, we notice specific statements as to those best adapted for photographing various parts of the spectrum, and the "high resolution plates," for which a "limiting separation of about 1/150th mm." is claimed, as against a separating power equal to about 1/40th mm. for ordinary plates. These special plates are slow panchromatic plates.

OUR ASTRONOMICAL COLUMN.

DETONATING METEOR IN MESSINA.—On Monday evening, April 10, at 7 p.m., people at Messina noticed a brilliant illumination of the sky, succeeded in about three minutes by four loud explosions like artillery discharges. The idea was that one of the ammunition magazines in a fort had exploded, but telegraphic despatches from Palermo, Catania, and Reggio di Calabria announce that a similar phenomenon had been remarked there, and that it had its derivation from a large bolide or some other meteoric disturbance. The interval of three minutes between the flash and sounds show that the disruption of the fireball occurred at a distance of about forty miles from the observer at Messina. More information is awaited. At other stations the object may have approached much nearer, if it did not, indeed, shower some of its disintegrated fragments to the ground. April 10 is a rather special date for large fireballs; it has furnished many fine specimens in past years.

HALLEY'S COMET.—Writing to the *Astronomische Nachrichten* (No. 4489), M. Antoniadi shows that whilst Prof. Eginitis recorded the tail of Halley's comet as being directed towards the sun at 6h. 40m. (G.M.T.) on May 20, 1910, five observers who saw it at various short intervals before that time, and five who saw it after, recorded the tail as directed from the sun; only twenty-nine minutes separated the times of observation at Sonnwendstein and Athens, the former being 7h. 9m. (G.M.T.). Mr. Evershed, observing at Kodaikánal about 2h. (G.M.T.) on May 20, saw no trace of a tail directed towards the sun, although he looked specially for it.

The same number of the *Astronomische Nachrichten* contains a long series of observations of the comet made at Besançon (December 10, 1909, to June 29, 1910) and at Berlin (December 16 to June 10); M. Chofardet reproduces a drawing showing the magnificent fan which preceded the sharp nucleus on May 27.

CIRCULATION IN THE SOLAR ATMOSPHERE.—From an examination of 3323 prominences shown on photographs taken between January, 1904, and December, 1910, with the Rumford spectroheliograph at the Yerkes Observatory, Dr. Slocum has derived some valuable data concerning the circulatory currents in the solar chromosphere; the light of the H calcium line was always employed. Of the total examined, 1094 prominences, either by their shapes or movements, indicate a horizontal current, and as the average height to which these extended was 0·7′, or 30,000 km., the results represent the average poleward components of the solar atmospheric circulation from the lower surface of the chromosphere up to that height. Dr. Slocum finds that in middle latitudes there is a tendency for movement towards the poles, and in high latitudes a tendency towards the equator; near the equator the motion is practically negligible. The contrast between the two tendencies is greater in the northern hemisphere in the ratio of at least 2 : 1.

Among the earlier plates there were few which afforded data from which the velocities of the motions could be determined, but during the past year suitable plates for this purpose have been taken regularly. There is some difficulty in determining which of the observed movements may be ascribed to systematic circulation and which to local explosive outbursts, but ten selected cases give velocities of from 0·5 km. to 10 km. per second for the component of the circulatory movement which is perpendicular to the line of sight; one detached cloud, floating at an elevation of 442″, or 320,000 km., showed a velocity of 50 km. per second. Dr. Slocum points out that these results are not necessarily a contradiction to those obtained by Dr. St. John, who failed to detect any currents of appreciable velocity parallel to the solar surface; the two researches deal with different levels in the solar atmosphere. He further suggests that as his results depict the movements at an average height of 30,000 km., they probably apply to an upper current analogous to terrestrial anti-trades; a later discussion to deal with the different levels is promised (*Astrophysical Journal*, vol. xxxiii., No. 2, p. 108).

THE POPULARISATION OF ASTRONOMY.—From *The Yorkshire Weekly Post* for April 8 we learn that the excellent idea of out-of-door astronomical talks has also been suggested by Mr. J. H. Elgie as a useful item in the programme of the Leeds Astronomical Society. For the past three weeks the society has been waiting, in vain, for a favourable sky so that they might hold the proposed Saturday evening meeting. Such meetings, open to the public, might easily be organised, and would probably do a great deal to dissipate the lamentable ignorance concerning the stars which is so frequently displayed by the general public.

THE ANTWERP ASTRONOMICAL SOCIETY.—Among the many interesting matters recorded in the sixth annual report (1910) of the Antwerp Astronomical Society, it is of interest to learn that the society's observatory is being very generally used by a large number of students in the local schools, who, under the guidance of their tutors, visit the observatory and have the equipment, &c., explained to them. A new communal observatory is to be placed on the top of a school which is in course of erection in the city. An analysis of the observing weather during 1910, made by M. Felix de Roy, is also of interest. Of the 365 days in 1910, observations of the sun were possible on 269 days, and night observations were possible on 142; for 1909 the figures were 292 and 151; in 1908 there were 156 good nights; in 1907, 145; and in 1906, 102.

SPECTROSCOPIC BINARIES.—The Journal of the Royal Astronomical Society (Canada, vol. iv., No. 6) contains the orbits of the spectroscopic binaries 93 Leonis and ϵ Ursæ Minoris as determined by Messrs. J. B. Cannon and J. S. Plaskett, respectively, from plates taken at the Dominion Observatory, Ottawa.

Mr. Cannon made two determinations, using micrometer measures in the first and the comparator in the second, and, judging from the probable errors of an average plate, there is but little difference between the two methods; fainter spectra may be measured with the micrometer than in the comparator, but with poor lines for measurement the latter instrument probably affords a better agreement among the measures. The period of 93 Leonis is found to be 71·7 days, and the eccentricity of the orbit is very small.

For ϵ Ursæ Minoris Mr. Plaskett finds a period of 39·482 days, a range of velocities of 63 km. per sec., and a small eccentricity; the velocity of the system is −11·398 km. per sec.

EXPERIMENTS WITH COAL DUST IN FRENCH COLLIERIES.

SOON after the dangers due to the presence of coal dust began to be realised in this country, and, as a consequence, regulations regarding the composition and methods of employing explosives in dusty mines had been added to the Statute-book, the number of great explosions occurring within a given time underwent such a remarkable diminution that for several years it seemed almost as if they were about to cease altogether. But a partial

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recrudescence having set in later, it became apparent to those who were watching the course of events that complete immunity could not be attained until measures were adopted for dealing with the coal dust in the haulage roads, as well as at the points at which blasting shots were about to be fired. It was equally apparent that no far-reaching legislative action such as this could be taken unless the mining community, which had hitherto regarded the dangers of coal dust as more or less hypothetical, could be convinced of their reality, by ocular demonstration on a large and imposing scale. Accordingly, when called upon to give evidence before the Royal Commission on Mines some years ago, the present writer and others recommended the construction at Government expense, at an estimated cost of 10,000*l*., of a large apparatus to be used for this purpose. It is, perhaps, needless to remark that the Treasury declined to find the money, just as they had, some twenty-nine years ago, declined to find 5000*l*. for the construction of a similar gallery, 500 feet long by 6 feet in diameter, intended to be used for the same educative purpose, when asked to do so by the Royal Commission on Accidents in Mines, for one of the members of which (Sir W. Thomas Lewis) the present writer had obtained tenders.

The suicidal blindness of this kind of policy from a national point of view must surely be becoming apparent. It was at this juncture that the Mining Association of Great Britain stepped in and erected the experimental gallery at Altofts Colliery, which has been already described in a previous review (NATURE, February 9, vol. lxxxv., p. 487).

When it was recognised in France that the explosion at Courrières Collieries, which claimed more than 1100 victims in 1906, was due to coal dust alone, the opposition which the Commission du Grisou had, up to that time, maintained against the coal-dust theory was effectually crushed, and it became necessary for those responsible for the safety of French mines either to accept the data regarding the behaviour of, and means of dealing with, coal dust already accumulated in other countries, or to accumulate quasi-original data of their own. The opportunity of adopting the latter alternative presented itself when the Comité Central des Houillères de France agreed to find a capital sum of 14,000*l*. wherewith to provide experimental appliances, and an annual income of 3000*l*. a year for current expenses as long as the experiments are continued.

The appliances which have been set up at Liévin Collieries in France are similar to, and intended to serve the same purposes as, those at Altofts and other experimental stations.

The experiments are being conducted by M. Taffanel, a member of the Corps des Mines, who has issued consecutively a number of very clear and able reports, describing the appliances, the methods of using them, and the results obtained with them.

In attempting, in his first report, to justify the attitude of antagonism to the coal-dust theory which his colleagues had just abandoned, he essays to throw a dart at the work of the present writer, but the weapon, having the form of a boomerang, naturally descends upon the unhappy heads of those he is trying to protect. It could not well be otherwise, for his subsequent voluminous descriptions of the mode of occurrence of a coal-dust explosion, the functions of the condensed and expanded waves and the position of the flame in the former, the influence of the weight of dust in a given volume of air, its fineness, the proportion of volatile matter contained in it, and the presence of more or less inert matter and moisture, had all been anticipated in the work in question; so that his own contributions to the subject, when divested of a vast amount of prolixity and a great array of numerical data, much of which is of doubtful, and most of only hypothetical value, largely partake of the nature of plagiarism.

Numerical data obtained by means of experiments of this kind are of no practical value except in so far as they can assist us in devising means for putting an end to great explosions. Thus, as it is known that the flame of an explosion in a mine can ascend to the top of a damp or wet shaft 900 or 1000 feet deep, it is not of the least importance to know whether an explosion in an experimental gallery can or cannot leap across a dustless zone a few hundred feet in width, and raise and ignite coal dust lying at its farther side. It is equally unimportant to know with what velocity the flame travels in, or what particular pressure is exerted by, an explosion of dust of greater or less fineness, or containing more or less volatile matter, since we are absolutely powerless to regulate any one of these conditions in a dusty mine, and know that an explosion, once begun in it, will spread as far as there is coal dust to maintain it.

In further attempting to cover the retreat of his comrades, M. Taffanel pleads that they had no previous experience of coal-dust explosions in France before the one at Courrières Collieries. But the present writer has a lively recollection of reading the accounts of two great explosions at the Jabin pits in France, which occurred one after the other within a short period of time, some thirty or more years ago, and of making a mental note at the time that, judging by the phenomena as described, they were both due to coal dust and not to firedamp, as was then announced. Again, surely M. Taffanel does not now seriously contend that the four great explosions, Chatelus, 1887, Verpilleux, 1889, Pelissier, 1890, and Manufacture, 1891, were attributable to any other agent than coal dust.

We frankly agree with M. Taffanel that his countrymen are, as a rule, in the van of progress; that although they did not originate the method of measuring the proportion of firedamp in the air by means of the firedamp cap (*for this see* Proc. Roy. Soc., vol. xxiv., pp. 361 to 367), they have produced an excellent lamp for the purpose; and that their appliances and regulations for dealing with firedamp, and for blasting, are amongst the most perfect in existence, and we heartily congratulate him and them upon the results of these measures. But *qui s'excuse s'accuse*: and the mere fact that they have been able to perfect their methods of dealing with firedamp makes it all the more regrettable that they so resolutely refused to believe in the dangers of coal dust, since it is practically certain that had they lent their powerful aid to the solution of that question from the beginning, it would have been settled long ago, and at least two Royal Commissions which examined the subject successively in this country would have been saved the ignominy of making halting and half-hearted suggestions for grappling with it.

The first series of M. Taffanel's experiments was made with an auxiliary apparatus consisting of two pieces of sheet-iron pipe, each 25 feet long by 2 feet in diameter, placed side by side and connected to each other at each end by short pipes of the same diameter. The air was made to circulate through this system by means of a fan working at the middle point of one of the longer pipes with sufficient rapidity to keep fine dust suspended in it, and shots were fired from a cannon into the dust-laden air from one end or the other of the second long pipe. By this means it was ascertained that dust containing 11·3 per cent. of volatile matter (ash and moisture deducted) could not be ignited by the explosion of a half cartridge of gelatine dynamite fired electrically from the cannon without tamping, but that dust containing 15·4 per cent. and up to 53·2 per cent. could be invariably ignited when the air contained a minimum weight of 138 grammes per cubic metre of that with 15·4 per cent. and 40 grammes per cubic metre of that with 53·2 per cent., and similarly an intermediate weight for an intermediate proportion of volatile matter.

The second series of experiments was made with the same apparatus (the shots being fired in the direction of the air current), one set to ascertain the effect of varying the weight of the explosive, the other to determine the effect of mixing the coal dust with slate dust. The coal dust employed was prepared with Liévin coal containing 29 to 30 per cent. of volatile matter and 3 to 5 per cent. of ash, and of such a degree of fineness that only 5 per cent. of it was unable to pass through the sieve with 5625 meshes per square centimetre.

By these experiments it was ascertained, first, that a certain minimum weight of explosive was sufficient to produce ignition, and that increasing that weight made little or no difference in the length of the resulting coal-dust flame; and, secondly, that the addition of slate dust to the coal dust reduced the velocity of propagation of the flame, although inflammable clouds were obtained with as much as 62 per cent. of slate dust, and it seemed doubtful whether under certain conditions propagation would not take place with as much as 78 per cent.

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These results are to some extent in keeping with those obtained by the present writer on June 5, 1896, when he made the first experiments of this kind with mixtures of combustible (in that case lycopodium) dust and inert dusts (chloride of calcium, dry clay, common salt) at University College, Cardiff, in the presence of Mr. Robson, then Chief Inspector of Mines for the South Wales district, and Mr. Vaughan Nash.

The third series of experiments was made with the principal gallery, which in 1908 was 71 yards long, in 1909 was lengthened to 250 yards, and in 1910 to 328 yards. The first 33 yards of its length is constructed with ferro-concrete specially strengthened with steel joists. Its form is trapezoidal in cross-section, and its internal dimensions are 6 feet high, 4 feet 7 inches wide at the top, and 5 feet 3 inches wide at the bottom. This shape and these dimensions were chosen with the object of assimilating its interior to that of a roadway in a mine, and the similarity is still further accentuated by means of props and caps set up at the usual distances apart in its interior. In its final form, so far as one can gather from the descriptions, the remainder of the gallery is constituted by a sheet-iron cylinder, 6 feet in diameter, with one of its ends abutting against one end of the ferro-concrete section and its other end open.

Two massive stone walls, one on each side of the free end of the ferro-concrete part of the gallery, extend backwards from the latter to a distance of 10 or 12 feet, and constitute supports to a vertical barrier of strong wooden beams, with which that end is closed. The cannon from which charges of explosive are fired for the purpose of igniting mixtures of firedamp and air, or of raising and igniting coal dust in the interior of the gallery, can be fired horizontally at any desired height in the vertical centre-line of the latter, with its muzzle extending through a hole in, and flush with the inner face of, the wooden barrier. Its bore is 2 inches in diameter and 23½ inches deep, and, except where specially mentioned to be otherwise, its axis was placed at a height of 2 feet above the floor. The explosive employed was gelatine dynamite fired without tamping by means of an electric fuse, and the minimum weight of charge that assured propagation of the coal-dust flame under ordinary conditions was 160 grammes.

A branch gallery built of masonry, connected at right angles to the main gallery at a distance of about 17 feet from its closed end, serves the purpose of a channel, through which air can be blown, by means of a ventilating fan, into and through that gallery, and also affords a means of ingress to and egress from it.

When an explosion is about to be produced, the connection between the main and branch galleries is cut off by closing a strong door at their point of junction.

There are twelve plate-glass windows about the middle height of the ferro-concrete part of the gallery, through which the progress of flame in its interior can be seen from a distance. Its cylindrical prolongation, on the other hand, is embedded in the centre of a mass of debris, like a railway embankment, about 6 feet high by 12 feet wide at the top, and with sloping sides.

The coal dust employed in the experiments is obtained by grinding coal as it comes from the mine, first in a ball-mill, and secondly in an Alsing pulveriser. The degree of fineness attained in the latter depends upon the length of time during which the grinding is continued.

After having been first granulated in the ball-mill and then ground in the Alsing pulveriser for the length of time named below, the following proportions of Liévin coal are arrested by a sieve of brass wire with 5625 meshes per square centimetre,[1] viz. :—

Time	Per cent remaining on seive
0 minute	72·5
15 ,,	35·0
30 ,,	12·5
45 ,,	3·5
60 ,,	1·5

Some analyses of the same coal employed in the experiments are as follows :—

	Per cent.	Per cent.	Per cent.
Volatile matter (including moisture)	28·00	25·07	29·50
Ash	8·57	12·16	5·97
Volatile matter (exclusive of ash	30·60	29·30	31·40

The weighed quantity of dust employed in each experiment was scattered uniformly over the floor of the gallery by hand; that remaining unconsumed after the experiment was partly swept, partly blown out, by means of a strong current of air from the fan; and when it was desired specially to cleanse the gallery, jets of compressed air were employed for the purpose.

When it was desired to effect the ignition of the dust by means of an explosion of firedamp and air, part of the gallery next the wooden barrier was isolated by means of a paper diaphragm in exactly the same way as was first done for the same purpose in the Royal Society gallery of 1880–1, and afterwards in the Prussian gallery of 1884, and the gas and air already mixed was introduced into it in exactly the same way as an accurately measured quantity of firedamp was introduced into the isolated part of the Royal Society gallery, in which it was mixed with the air by being drawn into the centre and expelled from the periphery, of a rapidly revolving fan in the interior of the gallery itself.

The apparatus employed for measuring pressures is of the "crusher type," such as is employed in testing explosives. It consists of a cylinder, containing a hollow piston with a block of lead in its interior, and a small steel ball interposed between the block of lead and a fixed support. The pressure acts on the piston which presses the lead against the steel ball, and the latter, being prevented from moving by the fixed support, penetrates the lead to a greater or less depth. In spite of the extreme accuracy with which it is professed that the depressions produced in the lead block can be measured, a more clumsy and probably inaccurate method of measuring the comparatively small pressures here requiring to be dealt with could hardly well be imagined.

The appliance for measuring velocity, which consists of a counter marking fifths of a second, started at the moment the explosion commences and stopped by an observer when the flame appears at the end of the gallery, the length of which for this series of experiments appears to have been 65 metres only, seems to be hardly less trustworthy than the pressure recorder.

On the other hand, the flasks for collecting samples of the products of combustion immediately after the passage of the flame, from which the air had been extracted beforehand, and into which nothing could enter until a sealed glass tube which communicated with their interior had been broken by a detonator ignited by the flame of the explosion, seem to be satisfactory.

The firedamp employed in some of the experiments was obtained from the pit near at hand, stored in a gasometer, and mixed with air in the proportion of 9 or 10 per cent. before being introduced into the isolated part of the gallery in the manner already indicated.

Of all the explosives tested, dynamite was found to produce coal-dust explosions with the greatest facility. It was found that the explosion of 8 cubic metres (282½ cubic feet) of a mixture of firedamp and air, when ignited by means of 100 grammes of black powder, easily gave rise to a coal-dust explosion under favourable conditions; but that under less favourable conditions the superposition of a firedamp explosion upon that of dynamite actually diminished the chances of propagation. M. Taffanel's attempt to explain this phenomenon, by supposing that the large quantities of carbon dioxide and water vapour projected into the dusty atmosphere in consequence of the combustion of the firedamp are responsible for this result, is altogether erroneous. The true explanation is that the expanded wave, following after the condensed wave in the *cul-de-sac* constituted by the little gallery, overtakes and extinguishes the flame. The present writer observed the same phenomenon in his smaller Royal Society gallery of 1877–8, and succeeded in destroying the expanded wave and securing free propagation of the coal-dust explosion on every occasion by providing a flap-valve, opening inwards only, at the closed end of the gallery, through which air was drawn with sudden violence an instant after the firedamp mixture had exploded; and he has no doubt that M. Taffanel would have exactly

[1] Comite Central des Houillères de France Station d'Essais de Liévin-Troisième Serie d'Essais, p. 9 (1910).

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the same experience if he provided either a similar valve or a reservoir of air of sufficient capacity near the closed end of the *cul-de-sac* (such as exists in the form of branch workings in most mines), from which air could expand and thus wholly or partially destroy the vacuum. If he arranged his experiment in this way, he would have no difficulty in securing propagation by means of a firedamp explosion ignited by a spark, much less by 100 grammes of dynamite.

Many other points of importance might be referred to with advantage, but space would fail us were we to attempt to go further in this place, and the final remark we would make in regard to this series of experiments is that the water employed in damping the dust, which forms globules on the surface of the latter, does not appear to have been applied in the form of an exceedingly fine spray, repeated several times, in succession, with a short interval between each application, and we venture to think that if this had been done the results would have been different from those actually experienced.

The fourth series of experiments was made with the gallery lengthened to 230 metres (251½ yards), although the whole length was not always employed. For the first 32½ yards the form of the gallery was trapezoidal, with a lining of cement, the remainder cylindrical, with a lining of wood and with a floor. The coal dust was prepared from Liévin coal, with 29 to 31 per cent. of volatile matter and 6 to 12 per cent. of ash. The slate dust employed in some of the experiments was obtained from the pit. It contained 9 per cent. of volatile matter and 87 per cent. of ash, and was mixed with marly chalk, clay, siliceous sand, and boiler-furnace cinders. Mixtures of coal dust and inert dust were prepared by grinding them together. The mixture was simply spread uniformly on the floor and not stirred up mechanically before the explosion. The charge employed in creating the explosions consisted of 240 grammes of gelatine dynamite untamped and fired electrically, the axis of the cannon being 15¾ inches above the floor.

Fine dust was spread to a distance of 16½ feet in front of the cannon to insure ignition, but beyond that point coarser dusts ground for a quarter or half hour and even grains were employed.

Some explosions effected with half-hour dust were very violent, traversing the whole length of the gallery in 1½ seconds, with increasing velocity, which exceeded 1100 yards per second at the orifice, while the pressure, which was 28½ lb. per square inch for most of the distance, increased to between 42½ lb. to 71 lb. per square inch at 45 metres from the orifice, and to 156½ lb. per square inch at 11 yards from the orifice. With 900 grammes per cubic metre of quarter-hour dust, the flame traversed the gallery in 1·23 seconds, and the pressure attained 224 lb. per square inch at 10 metres from the orifice.

With a deposit of coal dust containing up to 33 per cent. of slate dust the coal dust was exploded, and the explosion was capable of becoming violent.

Passing over the experiments with dustless, watered and shale dust zones, and those made with obstacles of various heights, placed on the floor and on shelves at the sides of the gallery, we come to what are the most novel, and perhaps also the most interesting, of all the experiments, namely, the efficient results obtained in the way of arresting even violent explosions by placing loose, easily displaced cinders, or, *mutatis mutandis*, half-round sheet-iron tanks 40 inches long by 8 inches in diameter, filled with water on transverse planks one metre apart just under the roof of the gallery. It is to be hoped that these two methods of arresting explosions will be the object of further successful experiments, and it is not improbable that, after all, we may owe to France a debt of gratitude for pointing out a simple and efficacious means of effecting the object which all of us are so anxious to attain. May the present writer suggest in conclusion that possibly appliances of the nature of extincteurs or fire extinguishers, put into operation by the blast which precedes the flame of an explosion acting upon a movable vane which would open the passage for the escape of their contents, might be used instead of open troughs filled with water? The former would possess the indubitable advantage that they would retain their efficiency intact for any length of time; whereas the latter would require constant attention in the way of cleaning and refilling them. W. GALLOWAY.

THE INSTITUTION OF NAVAL ARCHITECTS.

THE spring meetings of the Institution of Naval Architects opened on Wednesday, April 5, at the rooms of the Royal Society of Arts. Owing to the death of Earl Cawdor, president of the institution, the chair was taken by Sir W. H. White, who announced that the council recommended the election of the Marquis of Bristol as president. The grant of a Royal Charter of Incorporation has received the Royal assent. The celebration of the jubilee of the institution, postponed from last year, will take the form of an International Congress on Naval Architecture and Marine Engineering, opening on July 4.

Fourteen papers were read and discussed. The problem of size in battleships was dealt with by Prof. J. J. Welch. Among other points raised in this paper is the contention that large dimensions expose a greater target to attack, a contention which must now be expanded to include the additional menace of missiles from dirigibles or aëroplanes. Assuming the attack to be delivered from a height of one mile, and therefore reasonably out of range of high-angle fire, a hollow bomb carrying 100lb. of explosive would take about twenty seconds to reach the water level, and would then have a striking velocity of about 500 feet per second. In twenty seconds a ship would change position some 540 feet, supposing her to be proceeding at 16 knots, and the probabilities of such a vessel being struck from above would be decreased if, at the moment of discharge of airship weapon, her helm were put hard over. The time, however, would not suffice to allow the vessel to sweep clear of her previous track before the missile reached water level, although the exposed area of deck in that track would be very much smaller than before. The difficulties associated with correctly judging speeds of battleships from the height named, and making proper allowance for cross wind currents, &c., combine to render a hit very uncertain if a single missile only is employed. It is stated, however, that arrangements are being made for dropping a number of such missiles from a single dirigible, in which case this form of attack would become a serious menace. It seems reasonable to suppose that the best protection from such attacks will be found in the counter-attacks by the same type of air-ship, associated with high-angle gun fire from the vessel attacked.

The Hon. C. A. Parsons and Mr. R. J. Walker gave the results of twelve months' experience with the geared turbines fitted to the cargo steamer *Vespasian*. In this vessel, the reduction of speed ratio of 20 to 1 is obtained by means of a spur wheel and pinion having double helical teeth. The vessel has now steamed 20,000 miles, and inspection shows that the wear in the teeth so far seems to be a negligible quantity. With the view of experimenting with different qualities of steel, a pinion of chrome nickel steel of tensile strength 55 tons per square inch, elastic limit 38 tons, and an elongation of 20 per cent. in a length of two inches, was tried and removed after two voyages. The corners of some of the teeth were found to be fractured, probably owing to irregular machining and to the material being too brittle. The original pinions were of mild chrome nickel steel of tensile strength 37 to 38 tons per square inch, and an elastic limit of 32 tons per square inch. These were replaced and have now carried the vessel more than 18,000 miles. A very noticeable feature has been the absence of racing of the engines under conditions when the propeller has been entirely out of the water. It is very difficult to observe any acceleration in the speed of the engines without the aid of a sensitive tachometer. This is owing to the very great angular momentum of the turbine.

Mr. G. S. Baker contributed a fully illustrated description of the National Experimental Tank and its equipment, including the model-making apparatus.

The whole of Thursday morning was taken up by a paper on Diesel engines for sea-going vessels, by Mr. J. T. Milton, of Lloyd's Register, a paper which provoked a very interesting discussion. Inducement to forsake the steam engine for ordinary sea-going vessels will be mainly the question of fuel economy. Even this important point would not of itself warrant a change to a new type of engine unless equal certainty of continuous efficiency on the voyages to be undertaken was provided, that is, as little risk of accident to machinery and as great facility for using temporary expedients for reaching port in case of break-

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